Lunar Superconducting Magnetic Energy Storage (LSMES). M. E. Evans[1] and A. Ignatiev[2], [1]NASA Johnson Space Center, michael.e.evans@nasa.gov, [2]University of Houston, ignatiev@uh.edu.

Introduction: Superconducting Magnetic Energy Storage (SMES) is an energy storage system that stores electrical energy in the form of a magnetic field by passing direct current through a superconducting coil. The conductor for carrying the current operates at cryogenic temperatures where it becomes a superconductor and thus has virtually no resistive losses as it produces the magnetic field. [1]. The energy can be stored in a persistent mode until required [2]. The main terrestrial challenge for SMES is the need for a cryo-cooling system and the cost associated with its deployment, operation and maintenance. For lunar and planetary exploration, this challenge is totally mitigated using the cold environment of the mission to sustain superconductivity temperatures. The permanently shadowed craters on the moon have regolith temperatures between 50-60K (3), which is the operating temperature for High Temperature Superconducting (HTS) wire. SMES provides several advantages over traditional chemical batteries that: 1) incur much energy loss in extremely cold environments due to power needed for heaters, 2) are inefficient due to their inherent redox and side reactions, and 3) fail over time due to charge/discharge cycling changes in their chemical processes.

Study for Application on Moon: Generally, a SMES system consist of four parts: 1) superconducting magnet; 2) cryogenic system; 3) control system; and 4) power conditioning system. This study initially identifies guidelines for a candidate mission using LSMES. Next, the study addresses the feasibility of using HTS wire in either a solenoid or toroid configuration, designs the magnet support structure considering the current carrying capacity of the magnet wire and the mechanical stresses associated with the high magnetic fields, and evaluates concepts for grid power conditioning and an electronic switch to charge/discharge the coil. The study also develops a hardware concept of the coil and tests energy storage in a magnetic field at expected lunar temperatures in the Permanently Shadowed Regions (PSRs).

Summary: LSMES could provide for energy storage with negligible electrical energy loss (>95% system efficiency) [4] at cryogenic temperatures (<100K) over very long lifetimes. Integrating LSMES into a mission architecture could enable creation of distributed electrical "recharge stations" for lunar surface components in both human and robotic missions. This technology is independent of the energy source and could be applied to architectures with either networks of solar arrays or nuclear fission reactors on the lunar surface. It could also be applied to other lunar regions with appropriate thermal gradients that support constant cryogenic temperatures outside the PSRs.

References:

[1] Onnes, H.K. (1911) *Comm. Phys. Lab. Univ. Leiden*, 124 [2] Chen, H. et al (2009) *Progress in Natural Science*, 291-312 [3] Williams, J.P. et al (2016) *Icarus 283*, 300-325 [4] Cheung, K.Y.C.et al (2002) *Imperial College London: ISE v2*.